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Radiometric measurement of forage quantity

Abstract

A 16-band multispectral radiometer (MSR) was used to measure the amount of forage biomass present on several dates in native tallgrass prairie pastures during the 1992 to 1994 growing seasons. Reflectance data collected with the MSR were used a s inputs for a neural network computer program. The neural network used the reflectance data to predict forage biomass. Biomass estimates made with the MSR were found to predict actual biomass, as measured by hand-clipping, across all plant growth stages with an error of approximately 6%. Radiometric determination of biomass is a reliable alternative to hand-clipping and can be accomplished in much less time.

Keywords

Cattlemen's Day, 1995; Kansas Agricultural Experiment Station contribution; no. 95-357-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 727; Beef; Multispectral radiometer; Biomass; Forage; Neural network

RADIOMETRIC MEASUREMENT OF FORAGE QUANTITY

K. C. Olson, R. C. Cochran, and G. Towne

Summary

A 16-band multispectral radiometer (MSR) was used to measure the amount of forage biomass present on several dates in native tallgrass prairie pastures during the 1992 to 1994 growing seasons. Reflectance data collected with the MSR were used as inputs for a neural network computer program. The neural network used the reflectance data to predict forage biomass. Biomass estimates made with the MSR were found to predict actual biomass, as measured by hand-clipping, across all plant growth stages with an error of approximately 6%. Radiometric determination of biomass is a reliable alternative to hand-clipping and can be accomplished in much less time.

(Key Words: Multispectral Radiometer, Biomass, Forage, Neural Network.)

Introduction

Measurement of pasture forage production (i.e., biomass) is essential for determining proper stocking rates and range condition. Current methods involve hand-harvesting of forage in some defined area (e.g., 1 m^2). This procedure must be repeated many times to adequately characterize the amount of forage in an entire pasture and is extremely slow and laborious. Multispectral radiometry (MSR) has the potential to predict forage biomass much more rapidly. It is based on the principle that every substance absorbs and reflects various wavelengths of electromagnetic radiation (i.e., sunlight) in a manner characteristic of its physical and chemical structures. The amount of sunlight reflected by a substance is directly proportional to its mass. Further development of this technology may allow estimation of chemical characteristics of forages, such as nitrogen.

Experimental Methods

One ungrazed and three grazed tallgrass prairie pastures, located at the Kansas State University Range Research Unit, were used in this study. Three soil types were identified within each pasture before the study began: loamy upland, limestone breaks, and thin claypan. Sampling times were late May, mid June, late July, late August, mid September, and mid October. At each sampling date, biomass on 30 to 120 plots was measured with the multispectral radiometer (MSR; Cropscan®, model MSR - 87). A total of 334 plots was measured. An equal number of samples was collected on each soil type. After a radiometric measurement was collected, a corresponding .25 m^2 area was clipped at ground level, and the forage was dried and weighed to determine actual biomass production. Reflectance information collected with the MSR was used as the input for a neural network. This is a computer program that simulates the inductive reasoning process in human beings. In this case, it was used to predict biomass from reflectance features of the forage. Biomass predicted via the MSR and neural network were compared with the actual weights of clipped samples.

Results and Discussion

Eleven categories of information relating to forage characteristics were used as inputs for the neural network (Figure 1). The categories that were most important in predicting biomass were reflectance at 510 nm, 610 nm, 660 nm, and 760 nm. The NDVI (normalized difference vegetation index; (810 nm – 610 nm)/(810 nm + 610 nm) was also important. The soil type and sunlight intensity (IRR) appeared to be less important in the final prediction equation.

Biomass was predicted by the MSR/neural network combination across season and soil type with an overall estimation error of 6.04% (Figure 2). The MSR/neural network appeared to predict clipped biomass very accurately when lower amounts of standing forage dry matter were present. However, the relationship appeared to become weaker with greater amounts of standing dry matter. This may have been due to the limited number of measurements available for large amounts of biomass and/or to forage growth characteristics. For example, more stem and leaf material is raised above ground level as biomass increases. As a result, leaves and stem material closer to the ground become shaded by the upper parts of the plant and may not reflect sunlight proportional to their surface area.

The MSR/neural network used in this study adequately predicted clipped forage biomass over a variety of forage growth stages and levels of biomass, although the accuracy of prediction appeared to be less with high amounts of forage biomass. Radiometers like the one used in our study should prove useful for rapid determination of forage biomass for stocking rate or rangeland monitoring purposes in the future.

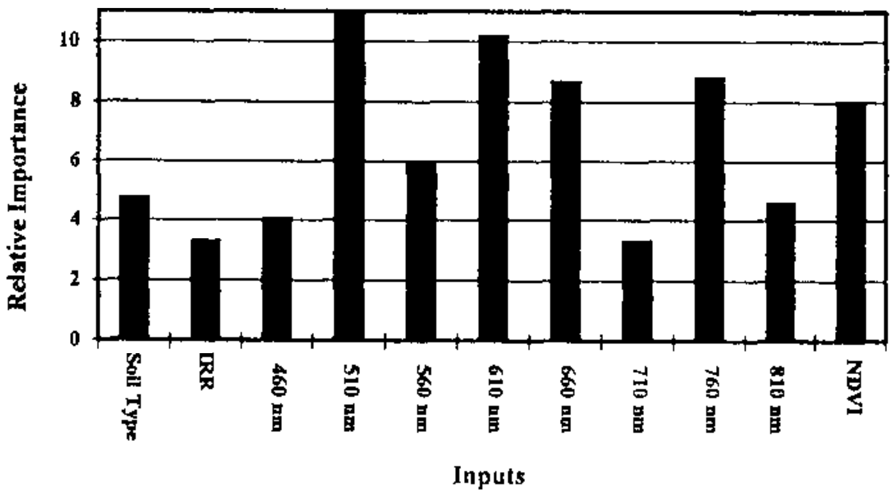

Figure 1. Relative Importance of Different Inputs. IRR Is Sunlight Intensity. NDVI Is Normalized Difference Vegetation Index. Numbers Are Wavelengths of Light in Nanometers

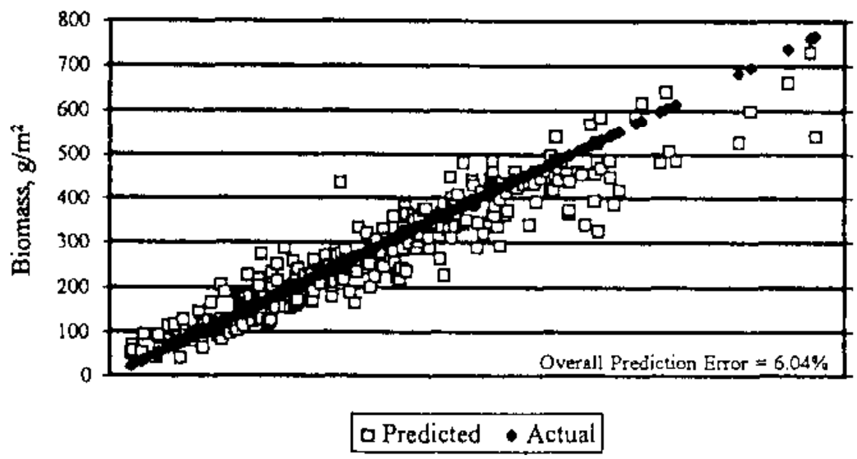

Figure 2. Actual vs Predicted Biomass